

Physics at the Art Museum: Swords and the Center of Mass

The design of swords uses the concept of center of mass to create a functional weapon that protects the user. Through this lesson, students will engage in an inquiry based science lesson using the Physics in Art app to learn about and apply the concept of center of mass. By the end of the lesson, students will be able to explain and demonstrate the application of the concept of Newton's Third Law by completing the guided notes while using the Physics in Art app and experimenting with center of mass in a lab.

Grade Level

Grades 6–9

Common Core Academic State Standards

- [CCSS. Mathematical Processes, Gr. 7](#)
- [CCSS.ELA-Literacy.RST.6-8.3](#)
- [CCSS.ELA-Literacy.RST.6-8.8](#)

Pennsylvania Academic Standards

- [9.1.8.A.1.](#)
- [9.2.8.A.](#)

Art Images Required

Click on the titles below to view high-resolution photographs on the Philadelphia Museum of Art website. Images that are also available in the Artstor Digital Library are indicated by an ID number or search phrase.

- [Hand-and-a-Half Sword \[1\]](#), 1525–50, made in Germany or Austria
Artstor: PMA_.1977-167-550
- [Hand-and-a-Half Sword \[2\]](#), 1475–1500, made in Italy
Artstor (related image): PMA_.F1938-1-104

Lesson Objectives/Essential Questions

1. What is center of mass?
2. How does the center of mass of an object change when weight is added to it?
3. Why does the center of mass of an object change when weight is added to it?

Suggested Vocabulary

angle	balance	friction
wedge	counterbalance	mass



Hand-and-a-Half Sword, c. 1525–50
Made in Germany or Austria
Steel [blade]; blackened iron, wood [hilt]; leather replaced
Overall: 10 3/8 x 45 11/16 inches (26.3 x 116.1 cm)
Bequest of Carl Otto Kretschmar von Kienbusch, 1977
1977-167-550

Lesson Process

PART 1: OBSERVING THE CENTER OF MASS

1. Have a student sit in a straight-back chair that has been placed against a wall in the classroom. Ask the student to stand up. Was it difficult? Describe the motion of the student as he/she stands.
2. Have another student sit in the chair, with his/her feet on the floor in front of the chair. Place your thumb on his/her forehead, preventing the student from leaning forward. Ask the student to stand up. Discuss why standing was impossible.
3. What is an object's center of mass? (Center of mass is the point at which an object is balanced.) Where is the center of mass of a seated person? What happened to the center of mass as the first student rose from his/her chair? What happened to the second student's center of mass that prevented him/her from standing?
4. Have students form pairs and try this experiment with a partner. The pairs should record their observations, findings, and conclusions regarding center of mass.

PART 2: CENTER OF MASS AND SWORDS, USING THE *PHYSICS IN ART* APP

1. Display the image (*Hand-and-a-Half Sword* [1]) and take a moment for students to observe closely.
2. Ask students to describe where they think the center of mass might be for this sword. Ask students to explain the reasons for their hypotheses. Discuss: why would it be important to understand center of mass and balance when using a sword?
3. Pass out copies of Appendix 1: Guided Notes (attached to this lesson plan). Open the Physics in Art app and have students complete the notes as they explore this section of the app.
4. Display the second image (*Hand-and-a-Half Sword* [2]) and take a moment for students to observe closely. Discuss what they have learned/discovered from the app, referring to the new sword image.
5. For what other objects is the center of mass important? List these. After you have created a list, see if you can organize them into groups. If so, the groups will reveal specific ways center of mass is important.

Assessment

Copy and pass out Appendix 2: Assessment (attached to this lesson plan). This may be completed in class or at home, at the discretion of the teacher.

Appendix 1: Guided Notes

Physics in Art: Center of Mass

DESCRIBE THE SWORD:

WHAT DO YOU SEE?

WHAT DO YOU THINK IT IS MADE OF?

DESCRIBE ITS TEXTURE AND FORM:

WHAT ARE SWORDS USED FOR?

DRAW A DIAGRAM OF THE TYPICAL MOTION OF A SWORD:

Appendix 1: Guided Notes (cont.)

WHAT DO THE DESIGNS OF THESE SWORDS HAVE IN COMMON?

1.

2.

3.

4.

THE ANATOMY OF A SWORD:

Cross-guard: Is the cross-guard for art or protection? Why?

Edge: How does the angle of the edge compare to the angle of a kitchen knife?

Hilt: Is the hilt for art or protection? Why?

Grip: Using your knowledge of physics, why might the grip be made out of leather?

Pommel: What is the purpose of the pommel? Why is it fitting that the word "pommel" means "little apple"?

WHAT MAKES AN IDEAL SWORD?

Appendix 1: Guided Notes (cont.)

THE POINT ON AN OBJECT THROUGH WHICH IT SEEMS THAT GRAVITY PULLS ON THE OBJECT IS THE:

WHAT HAPPENS WHEN YOU DO NOT SUPPORT AN OBJECT AT ITS CENTER OF MASS?

WHAT HAPPENS WHEN YOU DO SUPPORT AN OBJECT AT ITS CENTER OF MASS?

ON A HUMAN, THE CENTER OF MASS IS LOCATED NEAR:

WHAT ARE THE TWO THINGS THAT MATTER RELATED TO CENTER OF MASS WHEN WE ARE HOLDING AN OBJECT WHILE MOVING?

1.

2.

WHERE IS THE CENTER OF MASS ON A SWORD

WHAT IS THE FUNCTION OF THE POMMEL?

Appendix 1: Guided Notes (cont.)

HOW DOES THE PERSON'S ABILITY TO HOLD THE SWORD CHANGE WHEN THEY HOLD IT CLOSER TO THE CENTER OF MASS, RATHER THAN FAR FROM THE CENTER OF MASS?

Appendix 2: Assessment

Name _____ Date _____

DRAW A DIAGRAM OF A SWORD. INCLUDE THE PARTS OF ITS ANATOMY. LABEL THE CENTER OF MASS:

WHY IS THE CENTER OF MASS AT THE POINT YOU INDICATED ABOVE?